

World scientists' warning: The behavioural crisis driving ecological overshoot

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Abstract

Previously, anthropogenic ecological overshoot has been identified as a fundamental cause of the myriad symptoms we see around the globe today from biodiversity loss and ocean acidification to the disturbing rise in novel entities and climate change. In the present paper, we have examined this more deeply, and explore the behavioural drivers of overshoot, providing evidence that overshoot is itself a symptom of a deeper, more subversive modern crisis of human behaviour. We work to name and frame this crisis as 'the Human Behavioural Crisis' and propose the crisis be recognised globally as a critical intervention point for tackling ecological overshoot. We demonstrate how current interventions are largely physical, resource intensive, slow-moving and focused on addressing the symptoms of ecological overshoot (such as climate change) rather than the

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distal cause (maladaptive behaviours). We argue that even in the best-case scenarios, symptom-level interventions are unlikely to avoid catastrophe or achieve more than ephemeral progress. We explore three drivers of the behavioural crisis in depth: economic growth; marketing; and pronatalism. These three drivers directly impact the three 'levers' of overshoot: consumption, waste and population. We demonstrate how the maladaptive behaviours of overshoot stemming from these three drivers have been catalysed and perpetuated by the intentional exploitation of previously adaptive human impulses. In the final sections of this paper, we propose an interdisciplinary emergency response to the behavioural crisis by, amongst other things, the shifting of social norms relating to reproduction, consumption and waste. We seek to highlight a critical disconnect that is an ongoing societal gulf in communication between those that know such as scientists working within limits to growth, and those members of the citizenry, largely influenced by social scientists and industry, that must act.

Keywords

behaviour, ecological overshoot, scientists warning, pronatalism, marketing, psychology, ecology, economics, population, consumption

For Will Steffen (1947–2023), one of the kindest advocates for our planet in a time of crisis.

'The conscious and intelligent manipulation of the organized habits and opinions of the masses is an important element in democratic society. Those who manipulate this unseen mechanism of society constitute an invisible government which is the true ruling power of our country. We are governed, our minds are molded, our tastes formed, our ideas suggested, largely by men we have never heard of'.

– Edward Bernays, *Propaganda*, 1928

'A species causing the extinction of 150 species per day doesn't need more energy to do more of what it does'.

– Hart Hagan, Environmental journalist

Introduction

Modern humans and millions of other species face an unprecedented number of existential threats due to anthropogenic impacts exceeding our planet's boundaries.¹ We are in dangerous territory with instability in the known realms of biosphere integrity, land system change and novel entities such as plastics and synthetic toxins, climate change, freshwater change and biogeochemical flows.

Considering the dynamic, closed and interconnected nature of Earth's systems together, these threats pose an increasingly catastrophic risk to all complex life on Earth. Many scientists privately believe it to be already too late to avoid the tipping points that will trigger devastating and irreversible feedback loops.²

It is increasingly acknowledged that all of these threats are symptoms of anthropogenic ecological overshoot. Overshoot is defined as the human consumption of natural

resources at rates faster than they can be replenished, and entropic waste production in excess of the Earth's assimilative and processing capacity.³⁻⁷

In this paper, we explore the behavioural drivers of overshoot, providing evidence that overshoot is itself a symptom of a deeper, more subversive modern crisis of human behaviour. We work to name and frame this crisis as 'the Human Behavioural Crisis' and propose the crisis be recognised globally as a critical intervention point for tackling ecological overshoot. We demonstrate how current interventions are largely physical, resource intensive, slow-moving and focused on addressing the symptoms of ecological overshoot (such as climate change) rather than the distal cause (maladaptive behaviours). We argue that even in the best-case scenarios, symptom-level interventions are unlikely to avoid catastrophe or achieve more than ephemeral progress.

In the final sections of this paper, we propose an interdisciplinary emergency response to the behavioural crisis by, amongst other things, the shifting of social norms relating to reproduction, consumption and waste. We seek to highlight a critical disconnect that is an ongoing societal gulf in communication between those that know such as scientists working within limits to growth, and those members of the citizenry, largely influenced by social scientists and industry, that must act.

Scientists working in limits to growth must join forces with social scientists not only in academia but critically with the non-academic practitioners of applied social and behavioural science. Not only are such practitioners demonstrated masters in the theory of driving behaviour change but crucially also masters of the practical implementation of that theory in the real world.

Lastly, we will provide a possible frame through which to view our species' ability to consciously drive large-scale behavioural change as an opportunity unavailable to most other species. An implementation of such a framework limiting widespread maladaptive behavioural manipulation may ensure human appetites remain within planetary boundaries, and be key in unlocking a truly prosperous and sustainable future for *H. sapiens* on Earth.

This paper is not intended to be an exhaustive roadmap to address the behavioural crisis, instead it should be taken as a call to action for interdisciplinary collaboration to achieve just that.

Scope

In this paper, aside from reproductive behaviours which we mention below, our focus is largely confined to socially constructed attitudes, values and behaviours that encourage unnecessary personal consumption, and which have led the world into a state of overshoot.

This focus is critical because, to date, a mere quarter of humanity – the wealthy quarter – is responsible for 74% of excess energy and material use.⁸ This, when taken alone, is sufficient to propel the human enterprise into overshoot.

Meanwhile, the quarter of the global population who live below the USD \$3.65 poverty line, and the almost half, 47%, who live below the USD \$6.85 poverty line⁹ aspire to achieve equivalent high-end lifestyles, encouraged, in part, by the constant barrage of advertising. To achieve this would certainly increase greenhouse gas

emissions, deplete many essential renewable resources from fish-stocks to arable soils and strain global life-support to breaking point, including the risk of triggering runaway hothouse Earth conditions.¹⁰

We acknowledge that there are many other relevant behaviours and considerations, including genetic pre-dispositions to consume, the role of temporal, spatial and social discounting, socio-political factors (e.g. status hierarchies) and even addiction to conspicuous consumption.

Repeated rewarding experiences help shape the synaptic circuits of the developing brain, predisposing the individual to seek out similar experiences that reinforce the already preformed circuits and to deny or reject contrary inclinations or information.¹¹

We also acknowledge that part of our focus, on media and marketing manipulation, is just one example of how intentional behavioural manipulation undermines planetary and social health. There certainly are other examples – such as how firms and governments limit more sustainable options either by design or consequence. In essence, power dynamics in society underlie the manipulation of needs, wants and desires. This is crucial for understanding how our human predisposition for potentially maladaptive behaviours has been twisted to become actually maladaptive. While we humans are fully capable of regulating ourselves, power dynamics in societies often overcome this. Better understanding this within different societies, and how it perpetuates our ‘poly-crises’, will help us move into a wiser and more sustainable civilisation.

In regards to reproductive behaviours, population growth plays, and will continue to play, a significant role in ecological overshoot. Across the globe, the middle class is the fastest-growing segment of the population, projected to grow another billion to reach 5 billion by 2030.¹² Over the coming decades, the majority of projected population growth will be concentrated in the developing world,¹³ where the average standard of living must be raised through increases in per-capita consumption. As a result, however, their ecological footprints are likely to increase towards those of the Global North.

Proponents of ‘green growth’ may argue that there is a way to avoid this, however, ‘the burden of proof rests on decoupling advocates’.¹⁴

To avoid ecological breakdown ‘incrementalist propositions along the lines of green growth and green consumerism are inadequate. The ideals of sufficiency, material thresholds and economic equality that underpin the current modelling are incompatible with the economic norms of the present, where unemployment and vast inequalities are systematic requirements, waste is often considered economically efficient (due to brand-protection, planned obsolescence, etc.) and the indefinite pursuit of economic growth is necessary for political and economic stability’.¹⁵

Even the relatively conservative IPCC views population growth as a significant factor in climate change (a single symptom of ecological overshoot).¹⁶ Additionally, a recent paper found that population growth has cancelled out most climate gains from renewables and efficiency from the last three decades.¹⁷ For these reasons and more, we have not gone into detail on certain aspects of population dynamics. Instead, we have rooted this paper in ecological economics where population – at any level – plays an important role.

We call for additional research to develop a full understanding of the many dimensions of the behavioural crisis and how we can best address it.

Previous scientists' warnings

The initial 'World Scientists' Warning to Humanity' was published in 1992,¹⁸ starkly emphasising the collision between human demands and the regenerative capacity of the biosphere. It was followed by a further report, 'World Scientists' Warning to Humanity: A Second Notice'¹⁹ which confirmed that the intervening 25 years had merely accelerated environmental destruction driven by a global population increasing by more than 40% – some 2 billion humans. The 'World Scientists' Warning of a Climate Emergency' report,²⁰ so far endorsed by 14,859 scientists from 158 countries, proposed a range of measures for restoring and protecting natural ecosystems, conserving energy, reducing pollutants, reducing food waste, adopting more plant-based diets, stabilising population and reforming the global economy.

Subsequent warnings from the scientific community have added to the evidence of overshoot including insect extinctions,²¹ the impact of climate change on microorganisms,²² the freshwater biodiversity crisis,²³ endangered food webs,²⁴ invasive alien species,²⁵ the degradation of large lakes,²⁶ the illegal/unsustainable wildlife trade,²⁷ the role of affluence,²⁸ tree extinctions,²⁹ an imperilled ocean,³⁰ and population growth as a specific driver.³¹ These papers are gathered on the Alliance of World Scientists website.

Despite so many warnings, there has been a marked lack of action, driving several of us to co-author a 'World Scientists' Warnings into Action, Local to Global' paper,³² so far endorsed by over 3,000 scientists from more than 110 nations, to set out a framework for concrete action to curb our hyperconsumption of resources. This paper focused on the same six key issues (energy, pollutants, nature, food systems, population and the economy, plus governance and leadership), and on three timelines to 2026, 2030 and 2050. None of the key issues identified by the authors are isolated problems; they are all symptoms of human ecological overshoot.

In the present paper, we contend that an underlying behavioural crisis lies at the root of 'overshoot' and probe the implications for humanity if we are to retain a habitable planet and civilisation. While human behaviours were implicit in the various world scientists' warnings, we believe they need explicit attention and concerted emergency action in order to avoid a ghastly future.³³

Human behaviour drives overshoot

The main drivers of anthropogenic ecological overshoot are human behaviours and cultures relating to consumption^{8,28} and population dynamics.^{31,34} These two factors are mathematically, though certainly not linearly, related. Like other species, *H. sapiens* is capable of exponential population growth (positive feedback) but until recently, major expansions of the human enterprise, including increases in consumption and waste, were held in check by negative feedback – e.g. resource shortages, competition and disease – which naturally curbed continued population growth.⁷

H. sapiens took around 250,000 years to reach a global population of 1 billion in 1820, and just over 200 years to go from 1 billion to 8 billion. This was largely made possible by our species' access to cheap, easy, exosomatic energy, mainly fossil fuels. Fossil fuels

enabled us to reduce negative feedback (e.g. food shortages) and thus delay and evade the consequences of surpassing natural limits. In that same 200 year period, fossil energy (FF) use increased 1300-fold, fueling a 100-fold increase in real gross world product, i.e. consumption, and the human enterprise is still expanding exponentially.⁷ We are arguably in the late boom phase of a one-off boom-bust cycle that is driving us rapidly beyond the safe harbour of planetary boundaries towards chaotic collapse and worse (Figure 1).^{5,7}

In this paper, we use the term ‘behavioural crisis’ specifically to mean the consequences of the innate suite of human behaviours that were once adaptive in early hominid evolution, but have now been exploited to serve the global industrial economy. This exploitation has accumulated financial capital – sometimes to absurd levels – for investors and shareholders, and generated manufactured capital (‘human-made mass’) that now exceeds the biomass of all living things on Earth.³⁵ Significantly manipulated by the marketing industry, which several of us represent, these behaviours have now brought humanity to the point where their sheer scale – through our numbers, appetites and technologies – is driving ecological overshoot and threatening the fabric of complex life on earth.

These behaviours are related to our previously highly adaptive, but now self-defeating, impulses to:

- seek pleasure and avoid pain;
- acquire, amass and defend resources from competitors;

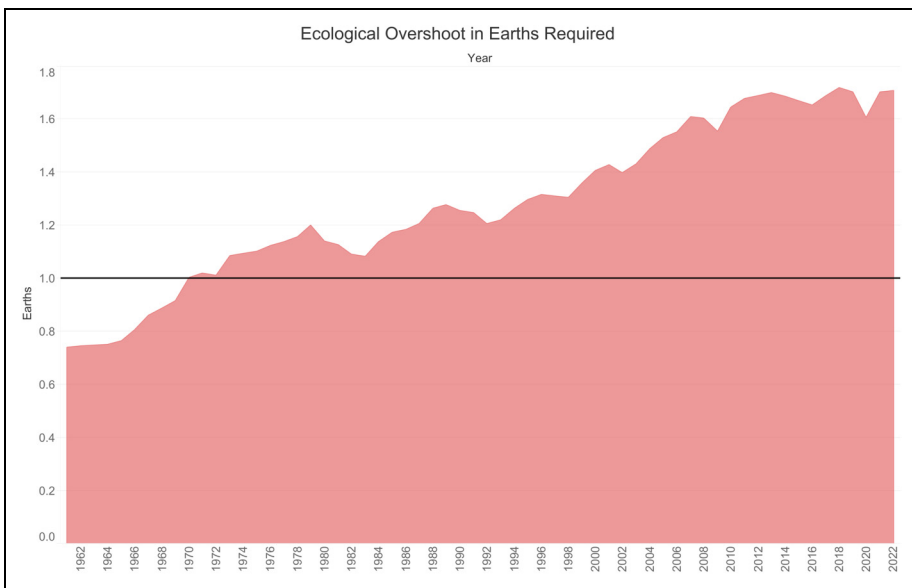


Figure 1. Ecological overshoot in number of Earths required. Data from Global Footprint Network – June 2023.

- display dominance, status or sex appeal through size, beauty, physicality, aggression and/or ornamentation;
- procrastinate rather than act whenever action does not have an immediate survival benefit particularly for ourselves, close relatives and our home territories (humans are innate temporal, social and spatial discounters).

Many of our continuing environmental and societal challenges arise from these hijacked impulses. In a global economy that strives to create and meet burgeoning demand, rather than fairly and judiciously apportioning supply, these behaviours are collectively highly maladaptive, even suicidal for humanity.¹

Drivers of overshoot behaviour

The evolutionary drive to acquire resources is by no means exclusive to the human animal. In *H. sapiens* however, the behaviours of overshoot are now actively promoted and exacerbated by social, economic and political norms largely through the intentional, almost completely unimpeded exploitation of human psychological predispositions and biases. Here, we explore what we consider to be three critical drivers in the creation and continuation of the human behavioural crisis.

Economic growth

Economists define the ‘economy’ as all those organised activities and behaviours associated with the production, allocation, exchange and consumption of the valuable (scarce) goods and services required to meet the needs and wants of the participating population. But this is a simplistic, limited definition. An ecologist might describe the economy as that set of behaviours and activities by which humans interact with their biophysical environment (the ecosphere) to acquire the material resources required for life, and to dispose of the waste materials that result from both our biological and industrial metabolisms. Economic accounts should therefore record all the energy and material ‘throughput’ from the natural world through the human subsystem and back into nature; they should even account for those produced goods that do not enter formal markets, as these add to gross material consumption. In other words, human economic behaviour helps define the human ecological niche, the role *H. sapiens* plays in interacting with, and altering the structure, function and species composition of, the ecosystems of which we are a part. From this perspective, economics really should be human ecology. But it is not.

Today’s dominant neoliberal economics conceives of the economy as a self-generating ‘circular-flow of exchange (monetary) value’ that operates separately from, and essentially independent of, the natural environment.³⁶ We generally measure the scale of economic activity in terms of gross national product, i.e. the abstract monetary value of final goods and services produced in a country in a specified time period. Physical natural resources (i.e. ‘the environment’) are seen as merely one of several interchangeable ‘factors of production;’ should a particular resource become scarce, we need

only increase the input of other factors (capital, labour, knowledge) or depend on rising prices to stimulate some engineer to find a substitute.^{37,38}

The same simplistic thinking conceives of humans as self-interested utility maximisers (i.e. 'consumers') with unlimited material demands and no attachment to family or community. It was easy for modern techno-industrial society to make the leap from believing that the economy is untethered from nature, people essentially insatiable and human ingenuity unbounded, to accepting the notion of unlimited economic growth fostered by continuous technological progress. This helps explain why real gross world product has ballooned 100-fold, and average per capita income (consumption) has increased by a factor of 14 (twice that in wealthy countries) since the early 1800s.³⁹

Interestingly, most people seem unaware that this explosion was made possible not only by improving population health but, more importantly, through technologies that use fossil fuels – coal, oil and natural gas. Fossil energy is still the dominant means – 81% of primary energy in 2022 – by which humans acquire sufficient food and other resources to grow and maintain the human enterprise. Between 1800 and 2021, global FF use increased by a factor of 1,402, from just 97 TWh to 136,018 TWh.³⁹ The average world citizen today uses 175 times as much FF as his/her counterpart in 1800. Remarkably, we humans have burned half the FFs ever consumed and emitted half our total fossil carbon wastes in just the past 30 years.⁴⁰

Marketing

Up until the early twentieth century, marketers focused on functional differentiation. The effectiveness of their work was largely contingent on its ability to 'spotlight' functional reasons to buy specific products when people needed them.⁴¹ In essence, the role of marketing was to connect functionally differentiated products with willing buyers. As markets matured, however, competition intensified, and businesses looked to find better ways to differentiate themselves beyond the purely functional.

Around this time, Sigmund Freud's nephew, Edward Bernays, began experimenting with his uncle's psychoanalysis work to develop techniques for widespread behavioural manipulation. Bernays later termed this *The Engineering of Consent*, describing it as the 'use of an engineering approach – that is, action based only on thorough knowledge of the situation and on the application of scientific principles and tried practices to the task of getting people to support ideas and programs'.⁴² Bernays successfully commercialised his work and is commonly regarded as one of the founders of the public relations industry. This novel approach, along with others developed in advertising agencies around the globe, proved highly influential on the way products were marketed and sold to consumers.

Suddenly, marketing effectiveness was no longer determined by its ability to 'raise awareness' or harvest existing demand but by its ability to deepen and diversify the needs and wants that could be met through personal consumption.⁴³ This paradigm shift meant that business growth was no longer constrained by people's mere biological requirements, it could instead be unlocked by attaching greater meaning to an effectively infinite number of market offerings.

In this brave new world of unchecked business growth, multinationals were no longer marketing hygienic toothpaste, but a mint-flavoured confidence boost – a maintenance purchase was suddenly something that could make you feel more attractive. Cars were no longer being sold based on their functional superiority (i.e. space, speed, comfort, price), but by what they suggested about you as a person (i.e. status, sexiness, rebelliousness, appetite for adventure).

In an era saturated by brands and marketing, consumption has become less reflective of our physical needs and more reflective of our runaway psychology. For example, we may buy to boost our mood, reinforce our identity⁴⁴ or elevate our social status above others.⁴⁵

The targeting of consumers has become increasingly effective through the collection and use of data and analytics. The collection and sale of individuals' personal data is rampant. Unsurprisingly, tech giants like Google and Facebook are amongst the most active in this space. These companies track and sell not only what consumers view online but also their real-world locations through what is known as RTB (Real-Time Bidding).

In the US, users' personal online data is tracked and shared 294 billion times each day (for your average American, that's 747 times per day). In Europe, that figure was found to be 197 billion times (Google alone shares this personal data about its German users 19.6 million times per minute). Combined that's 178 trillion times per annum.⁴⁶ All this leads to incredibly detailed data about individual user behaviours and preferences. In fact, a 2017 report found that by the time a US child reaches 13 years old, Ad Tech companies hold an average of 72 million data points on that child.⁴⁷

The subsequent egregious overconsumption, which in combination with the resulting creation of waste, disproportionately multiplied by population, gives the wealthy a far greater negative environmental impact than the poor.⁸ Individuals with incomes in the top 10% are now responsible for 25–43% of environmental impact and 47% of CO₂ emissions, while the bottom 10% contribute just 3–5% of environmental impact,²⁸ and the bottom 50% contribute only 10% of CO₂ emissions.⁴⁸ A recent report found the top 20 wealthiest individuals on Earth produce 8000 times the carbon emissions of the poorest billion people.⁴⁹

For sustainability, reductions in FF and material consumption between 40% and 90% are necessary.^{50,51} This may seem unattainable without a proportionate loss in living standards; however, affluent countries exist far beyond sufficiency. In fact, 'the drastic increases in societies' energy use seen in recent decades have, beyond a certain point, had no benefit for the well-being of their populations – social returns on energy consumption per capita become increasingly marginal'.¹⁵ As such, multiple studies now demonstrate per-capita energy consumption in many affluent countries could be decreased substantially and quality living standards still maintained.^{15,52–54}

Pronatalism

Reproductive decision-making is assumed to be a largely personal choice, free from the constraints of cultural and institutional norms. As a result, discussion of reproduction as it relates to environmental degradation and ecological overshoot is often met with concern

regarding impingement of people's personal desires, rights and actions. However, human reproductive behaviours, like most other behaviours, are greatly influenced by cultural norms and institutional policies and deserve to be investigated critically.^{55,56}

Pronatalism is a set of social and institutional pressures placed on people to have children, often driven by forces such as patriarchy, religion, nationalism, militarism and capitalism.⁵⁷ Pronatalism exerts enormous influence on people and their choices.

- Positive feedback is often expressed through glorification of motherhood and large families, financial incentives and subsidies for childbearing, including through assisted reproductive technologies.
- Negative feedback is expressed through stigmatisation of use of contraceptives, abortion and lifepaths that do not fit dominant cultural narratives, such as single adults, childless and childfree people, LGBTQIA+ people, adoptive families, those who regret parenthood or those who do not have the 'right' number of children.⁵⁸

Depending on the degree of patriarchal and institutional control in a given culture, stigma can take the form of physical and emotional abuse, divorce, economic marginalisation and social ostracisation.⁵⁶ The degree of policing individual parenting choices strongly determines the degree of conformity by individuals in a culture or community. This explains why women's stated preferences for number and timing of children vary in accordance with the norms of the community in which they reside.⁵⁵

Anthropological studies of later hunter-gathering societies as well as evidence of very early agricultural groups show that the shift to settlement societies led to a systematic diminution of female status, as women went from being active gatherers of food to being relegated to the home sphere, as males dominated the fields. The subsequent rise in population, cities and tribal conflict over land and power created the need for more laborers and warriors, which raised the value of women as child bearers to the exclusion of other roles, thereby underpinning the beginnings of pronatalism.⁵⁹

Due to the dangers associated with pregnancy and childbirth, as well as the laborious process of child-rearing, certain 'social devices' had to be employed to make reproduction appear more desirable, thereby population increase would offset the wastage of war and disease.⁶⁰ Social devices including the institutions of law, religion, media, education and medicine were used to promote and reinforce the universal idealisation of pregnancy and motherhood.

Over the last 200 years, improvements in public health, medicine, disease control and sanitation – all of which occurred on the back of fossil-fuelled industrialisation – significantly lowered the risk of dying, especially amongst children, leading to unprecedented growth in the human population. Pronatalism remains deeply embedded within institutional policies and norms that glorify and reward reproduction to serve external demographic goals – capitalism, religion, ethnocentrism and militarism amongst others.

Despite great advances in gender equality and opportunities for women in education and the economy over the last several decades, pronatalism remains a strong pillar in many societies. Most religious traditions have strong pronatalist teachings and scriptural mandates to 'be fruitful and multiply', further buttressed through misinformation about contraceptives

and abortion, and proscriptions on their use.^{57,58} Economists, political leaders and corporate elites regularly argue that keeping fertility high ensures a steady supply of workers, consumers and taxpayers, while generating a larger pool of potential inventors.⁵⁸

Neoliberal economic interests are also enacted through popular media and culture that perpetuate pronatalist narratives. From product advertising and women's magazines glorifying motherhood, and celebrity gossip fixation on the 'biological clock' and 'baby bump', to popular movies and television programmes that use pregnancy to 'complete' the character arc of a protagonist. The marketing, media and entertainment industries exert an enormous influence on people's reproductive decision-making.⁶¹

Meanwhile, neoliberal feminism – feminism of the privileged colonised by neoliberal ideology – seeks to advance political goals and enhance market value and has only reinforced the mandatory-motherhood narrative by advocating for women to 'have it all', a goal unattainable for the majority of women around the world. This new form of feminism has conveniently been exploited by the assisted reproductive technology industry, growing annually by 9%, with projected growth to a global \$41 billion industry by 2026 to market medically dubious technologies such as egg freezing to increasingly younger women.^{62–64}

Concerns about overpopulation in this century led authorities and advocates to institute campaigns and policies to reduce fertility rates. The majority of these policies, which employed measures to combat pronatalism by providing women the means to control their own fertility through access to education and family planning, proved extremely effective. Countries as diverse as Thailand, Indonesia and Iran saw their fertility rates drop from over six to under two in a matter of decades.⁶⁵ On the other hand, coercive policies such as China's one-child policy, and forced abortion and sterilisation campaigns in Puerto Rico and India, not only led to egregious violations of human and reproductive rights but they also backfired. They created the disastrous legacy of tainting all family-planning campaigns – including the majority that have focused on liberating women – with the blemish of coercion.^{34,65,66} These draconian measures not only led to widespread suspicion of any efforts towards population reduction and stabilisation but they also had the opposite effect of strengthening and legitimising the centuries-old form of reproductive control: pronatalism.⁵⁶ Currently, half of all pregnancies globally are unintended and 257 million women are unable to manage their own fertility due to oppressive pronatalist norms within their communities.⁶⁷

Given that the number of children that women desire is largely a social construct within a hegemonic framework of pronatalism, we must create a new cultural landscape that illuminates the fertility levels that women anywhere in the world might truly desire outside this construct. Fertility trends in every geography where women have greater reproductive autonomy point towards a tendency for smaller families – a choice that has been described as women's 'latent desire' for no or few children.^{66,68}

Addressing population growth, and the pronatalism that drives it, must become central to norm-shifting efforts in order to elevate reproductive rights while also promoting planetary health.

Tackling the behavioural crisis

Current interventions at the symptom-level often do more to maintain the status quo than to address the drivers of ecological overshoot. Accepted approaches are generally

technological interventions requiring immense amounts of raw materials and generating proportional ecological damage. For example, the much-hyped wholesale transition of our energy systems from fossil fuels to renewables would require daunting levels of raw material and fossil fuels in a futile struggle to meet humanity's ever-growing demands.^{69–72} Even if successful – which is not likely⁷³ – the energy transition would address only a single symptom of ecological overshoot, likely worsening other symptoms significantly in the process. As noted earlier, it is humanity's access to cheap, convenient energy that has allowed us to overshoot many planetary boundaries.^{7,74} Would anything else change simply because we substitute one form of energy for another?

Conversely, interventions addressing the behavioural crisis shift the focus from treating symptoms to treating the core cultural causes. Prioritising psycho-behavioural change over technological interventions may also have greater potential to relieve anthropogenic pressures on Earth. It would certainly greatly reduce the fossil fuels and material extraction required to maintain the human enterprise. An example of an intervention at this level could be the intentional creation of new social norms for self-identity to change human behaviours relating to consumption, population and waste.

Paradoxically, the marketing, media and entertainment industries complicit in the creation and exacerbation of the behavioural crisis, may just be our best chance at avoiding ecological catastrophe. Storytelling shapes appetites and norms: in this paper, we focus largely on the marketing industry, but we believe it important to highlight the potential of the media and entertainment industries for addressing the behavioural crisis also. Modelling behaviour through entertainment can be an extremely powerful way of driving behavioural change.⁷⁵ A real-world example of this can be seen through the telenovelas created by the Population Media Centre. PMC's broadcasts have been remarkably successful in changing reproductive behaviours in many countries through the role modelling of small family norms, delaying marriage until adulthood, female education and the use of family planning. In Ethiopia, pre and post-broadcast quantitative surveys found that listeners were 5.4 times more likely than non-listeners to know at least three family planning methods. Married women who were listeners increased current use of modern family planning methods from 14% to 40%, while use amongst non-listeners increased less than half of that.⁷⁶

It is also worth noting that when it comes to addressing maladaptive behaviours in the current paradigm, there appears to be a focus on raising awareness and education under the arguable assumption that this will lead to the desired behavioural changes. While awareness and education certainly have important roles to play in combating ecological overshoot, they are relatively ineffective at driving behavioural change.⁷⁷ Can the same behavioural mechanisms that built and fuelled our immense appetites bring them back within planetary limits to growth?

Lessons from the marketing industry

For more than 100 years, marketers, and recently behavioural scientists, have become proficient at influencing human desires, particularly consumer behaviour. The frameworks of persuasion they have developed could help bring humanity, and countless other species, back to safe harbour by reducing per capita consumption through the

celebration of lives of sufficiency, and setting healthy reproductive norms, all without triggering feelings of loss or regret in the general populace.

Though good marketing may seem like black magic, and the exclusive domain of a select number of creative ‘gurus’, it is actually an accessible and highly replicable system of proven practices and principles crafted to influence behaviour.

Broadly speaking, marketers strive to influence individuals’ felt wants and purchasing patterns in one of two key ways: by changing an individual’s perceptions of a product or by changing the social context in which specific forms of consumption take place. It follows that the same strategies can be put to use to redirect consumers’ behaviour rather than reinforcing the present consumption-based crisis. An individual’s belief about a product or service’s value relies heavily on how it is ‘framed’.

Tversky and Kahneman⁷⁸ have extensively demonstrated this framing effect, showing that people’s choices can be predictably shifted, not through changing the choices themselves, but by changing what consumers perceive as the salient qualities of available choices. For instance, advertising a yoghurt as 98% Fat Free is much more compelling than promoting the same product as containing only 2% milk-fat. Similarly, people who would be turned off by the promotion of a vegan diet may be completely receptive to the same regime when it is advertised as a plant-based or cholesterol-free diet.⁷⁹

Of the many ways to frame a new behavioural choice, the most successful will offer a clear and relevant benefit to switching. It is not, for instance, as effective to sell nicotine patches merely as a means to quit smoking as it is to promote them in terms of concrete personal benefits (e.g. better relationships, improved health, longer life, etc.). In short, if we were to effectively address the crisis of human behaviour, the desirable alternative behaviours (e.g. flying less, driving less, wasting less, having fewer children) must be creatively framed in ways that accentuate the benefits to the individual rather than highlight their personal sacrifices.

Human behaviour – like that of many other animals – is not driven merely by individual perceptions and values but also by the social context and system in which it occurs. In regards to the former, we act in ways that advertise our wealth, sexual prowess or social status.⁸⁰ Much like the peacock with its ornate tail or the stotting Springbok, humans have developed species-specific signals to demonstrate particular attributes or qualities to others.

While the intent of these signals remains largely the same across cultures and over time (i.e. to establish status, attractiveness, dominance, trustworthiness, etc.) the physical means of expression is constantly changing (e.g. from precious gold, silk or ivory in pre-industrial times to the prestige automobiles and expensive sound equipment in the 1980s, to the high-end computers, iPhones and understated AirPods of the 2000s). By better understanding what values and qualities people are trying to signal about themselves, we can design alternative perceptual framing that results in dramatically altered behaviour. For example, in one highly successful Australian road safety campaign, a team of marketers was able to effectively reframe the meaning of dangerous high-speed driving from signalling ‘masculine bravery’ to signalling ‘masculine insecurity’.⁸¹ Similarly, between 1979 and 2012, strategic efforts were made to reduce the practice of driving while under the influence of alcohol in the UK. Through decades of targeted marketing, community advocacy and police enforcement, the dangerous behaviour was

successfully transformed from exceptionally commonplace (i.e. performed by over half the male driving population) to exceptionally rare (i.e. viewed as unacceptable by 92% of the population).⁸²

This idea of signalling becomes particularly significant in light of the disproportionately negative impact that wealthy people have on the ecosphere through ‘conspicuous consumption’. While wasteful excess has historically been a reliable cross-cultural signal of social status, there is now promising evidence that this too is amenable to change in response to increasing eco-consciousness. Recent studies have pointed to a counter-signalling effect amongst wealthier populations, wherein more status is actually conferred to those who consciously try to impress by consuming less (e.g. driving modest cars, taking transit, wearing clothes from the thrift store, etc.).⁸³ By developing ways to positively socialise responsible behaviour, we can help people maintain their sense of self-worth and social status while reducing their contribution to ecological overshoot.

Although social norms may be shifting slightly in the right direction amongst the wealthy, such a values revolution is unlikely to occur in a time frame rapid enough to restore humanity to a survivable limits to growth scenario. In order to effect the rapid changes necessary to secure our long-term survival, we must consider how marketing, behavioural science and other direct instruments of social influence, including but not limited to the media and entertainment industries, might be used in an emergency response to accelerate the process. At the same time, we must find ways to support the billions of individuals who are greatly in need of increases in consumption to do so without inducing further planetary harm.

While the stigmatisation of ‘driving under the influence’ took decades, recent developments in social networks theory have shown that comparable changes are possible within a timescale of years. With a concerted, multidisciplinary effort by the aforementioned industries, radical change would likely be possible even sooner. The concept of the social ‘tipping point’ shows that as a belief or value spreads through a population, there is a catalytic threshold beyond which there is accelerated widespread adoption of that belief. Evidence suggests that this ‘tipping point’ can occur after just 25% of a study population has accepted the belief as a new norm.⁸⁴ This finding may be highly relevant to negate our behavioural crisis in an effective time frame.

Conceivably, there may be a ‘tipping point’ in social acceptance of the values associated with degrowth, where they are likely to become positively reinforced through various forms of media and entertainment without conscious participation. We urgently call for an emergency, concerted, multidisciplinary effort to target the populations and value levers most likely to produce the threshold effect, and catalyse rapid global adoption of new consumption, reproduction and waste norms congruent with the survival of complex life on Earth.

Directing and policing widespread behaviour manipulation

Behavioural manipulation has been intentionally used for nefarious purposes before, and as we’ve just explored, has played a critical role in the creation of the behavioural crisis and consequential ecological overshoot. Eco-centric behaviour is the heart of any

sustainable future humanity might wish to achieve. Moreover, we are at a crossroads, with three paths ahead:

- We can choose to continue using behavioural manipulation to deepen our dilemma,
- We can choose to ignore it and leave it to chance, or
- We can use an opportunity that almost no other species has had and consciously steer our collective behaviours to conform to the natural laws that bind all life on Earth.

This raises ethical questions, for example, who is worthy of wielding such power? At present, the answer is anyone with the necessary influence or financial means to exploit it. However, we should not entrust this to any individual human, company, government or industry. Instead, any continued use of widespread behavioural manipulation should be firmly bound by, and anchored within a framework built upon the laws of the natural world, as well as the science on limits to growth.

We urgently call for increased interdisciplinary work to be carried out in directing, understanding and policing widespread behaviour manipulation.

Conclusion

In summary, the evidence indicates that anthropogenic ecological overshoot stems from a crisis of maladaptive human behaviours. While the behaviours generating overshoot were once adaptive for *H. sapiens*, they have been distorted and extended to the point where they now threaten the fabric of complex life on Earth. Simply, we are trapped in a system built to encourage growth and appetites that will end us.

The current emphasis for overshoot intervention is resource intensive (e.g. the global transition to renewable energy) and single-symptom focused. Indeed, most mainstream attention and investment is directed towards mitigating and adapting to climate change. Even if this narrow intervention is successful, it will not resolve the meta-crisis of ecological overshoot, in fact, with many of the current resource-intensive interventions, it is likely to make matters worse. Psychological interventions are likely to prove far less resource-intensive and more effective than physical ones.

- We call for increased attention on the behavioural crisis as a critical intervention point for addressing overshoot and its myriad symptoms.
- We advocate increased interdisciplinary collaboration between the social and behavioural science theorists and practitioners, advised by scientists working on limits to growth and planetary boundaries.
- We call for additional research to develop a full understanding of the many dimensions of the behavioural crisis (including the overwhelming influence of power structures) and how we can best address it.
- We call for an emergency, concerted, multidisciplinary effort to target the populations and value levers most likely to produce rapid global adoption of new

consumption, reproduction and waste norms congruent with the survival of complex life on Earth.

- We call for increased interdisciplinary work to be carried out in directing, understanding and policing widespread behaviour manipulation.

The clock is ticking not only because the health of the natural systems upon which we are utterly dependent is deteriorating but also because broadscale interventions are only possible when a society holds together and is capable of coherent action. As the effects of overshoot worsen, the likelihood of societal breakdown increases. We still have an opportunity to be proactive and utilise the intact systems we have in place to deliver a framework for shifting social norms and other necessities for addressing the behavioural crisis. However, the day may come when societal breakdown will make intervention impossible, locking the planet into an unguided recovery that may salvage much of 'nature' but be inhospitable to human life.

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Note

1. We are aware that the term 'behavioural crisis' may be misunderstood by those familiar with government health department terminology, in which behavioural health is often specifically applied to addiction and mental health crises and disorders such as substance abuse, eating disorders and self-injury (University of Massachusetts Global undated). But this is not our usage of the term.

References

1. Rockström J, Steffen W, Noone K, et al. Planetary boundaries: exploring the safe operating space for humanity. *Ecol Soc* 2009; 14: art32.

2. Lenton TM, Rockström J, Gaffney O, et al. Climate tipping points – too risky to bet against. *Nature* 2019; 575: 592–595.
3. Catton WR. *Overshoot: The ecological basis of revolutionary change*. Illinois, USA: University of Illinois Press, <https://www.jstor.org/stable/10.5406/j.ctt1hfr0mh> (1980, accessed 20 June 2023).
4. Victor PA. *Escape from overshoot: Economics for a planet in peril*. British Columbia, Canada: New Society Publishers, Limited, 2023.
5. Rees WE. Ecological economics for humanity’s plague phase. *Ecol Econ* 2020; 169: 106519.
6. Rees W. Overshoot: cognitive obsolescence and the population conundrum. *J Popul Sustain* 2023; 7: 15–38.
7. Rees WE. The human eco-predicament: Overshoot and the population conundrum. *Vienna Yearb Popul Res* 2023; 21. doi:10.1553/p-eznb-ekgc
8. Hickel J, O’Neill DW, Fanning AL, et al. National responsibility for ecological breakdown: a fair-shares assessment of resource use, 1970–2017. *Lancet Planet Health* 2022; 6: e342–e349.
9. Schoch M, Kofi Tetteh Baah S, Lakner C, et al. Half of the global population lives on less than US\$6.85 per person per day. World Bank, <https://blogs.worldbank.org/developmenttalk/half-global-population-lives-less-us685-person-day> (2022, accessed 20 June 2023).
10. Steffen W, Rockström J, Richardson K, et al. Trajectories of the earth system in the anthropocene. *Proc Natl Acad Sci U S A* 2018; 115: 8252–8259.
11. Wexler BE. *Brain and culture: Neurobiology, ideology, and social change*. Massachusetts, USA: MIT Press, 2006. doi:10.7551/mitpress/1658.001.0001.
12. Kharas H. The unprecedented expansion of the global middle class. Published online 2017.
13. UN World Population Prospects (2022) https://www.un.org/development/desa/pd/sites/www.un.org/development/desa/pd/files/wpp2022_summary_of_results.pdf (accessed 22 August 2023).
14. Decoupling-Debunked.pdf, <https://eeb.org/wp-content/uploads/2019/07/Decoupling-Debunked.pdf> (accessed 22 August 2023).
15. Millward-Hopkins J, Steinberger JK, Rao ND, et al. Providing decent living with minimum energy: a global scenario. *Glob Environ Change* 2020; 65: 102168.
16. Shukla PR, Skea J and Slade R. Working group III contribution to the sixth assessment report of the intergovernmental panel on climate change.
17. Chaurasia A. Population effects of increase in world energy use and CO₂ emissions: 1990–2019. *J Popul Sustain* 2020; 5: 87–125.
18. World Scientists’ Warning to Humanity. <https://www.ucsusa.org/sites/default/files/attach/2017/11/World%2520Scientists%2527%2520Warning%2520to%2520Humanity%25201992.pdf> (accessed 20 June 2023).
19. Ripple W, Wolf C, Newsome T, et al. World Scientists’ warning to humanity: a second notice. *BioScience* 2017; 67: 1026–1028.
20. Ripple WJ, Wolf C, Newsome TM, et al. World Scientists’ warning of a climate emergency. *BioScience* 2020; 70: 8–12.
21. Cardoso P, Barton PS, Birkhofer K, et al. Scientists’ warning to humanity on insect extinctions. *Biol Conserv* 2020; 242: 108426.
22. Cavicchioli R, Ripple WJ, Timmis KN, et al. Scientists’ warning to humanity: microorganisms and climate change. *Nat Rev Microbiol* 2019; 17: 569–586.
23. Albert JS, Destouni G, Duke-Sylvester SM, et al. Scientists’ warning to humanity on the freshwater biodiversity crisis. *Ambio* 2021; 50: 85–94.
24. Heleno RH, Ripple WJ and Traveset A. Scientists’ warning on endangered food webs. *Web Ecol* 2020; 20: 1–10.
25. Pyšek P, Hulme PE, Simberloff D, et al. Scientists’ warning on invasive alien species. *Biol Rev* 2020; 95: 1511–1534.

26. Jenny JP, Anneville O, Arnaud F, et al. Scientists' warning to humanity: rapid degradation of the world's large lakes. *J Gt Lakes Res* 2020; 46: 686–702.
27. Cardoso P, Amponsah-Mensah K, Barreiros JP, et al. Scientists' warning to humanity on illegal or unsustainable wildlife trade. *Biol Conserv* 2021; 263: 109341.
28. Wiedmann T, Lenzen M, Keyßer LT, et al. Scientists' warning on affluence. *Nat Commun* 2020; 11: 3107.
29. Rivers M, Newton AC, Oldfield S, et al. Scientists' warning to humanity on tree extinctions. *Plants People Planet* 2023; 5: 466–482.
30. Georgian S, Hameed S, Morgan L, et al. Scientists' warning of an imperiled ocean. *Biol Conserv* 2022; 272: 109595.
31. Crist E, Ripple WJ, Ehrlich PR, et al. Scientists' warning on population. *Sci Total Environ* 2022; 845: 157166.
32. Barnard P, Moomaw WR, Fioramonti L, et al. World scientists' warnings into action, local to global. *Sci Prog* 2021; 104: 368504211056290.
33. Bradshaw CJA, Ehrlich PR, Beattie A, et al. Underestimating the challenges of avoiding a ghastly future. *Front Conserv Sci* 2021; 1.
34. Tucker C. Bending the curve by 2030: on the path to a population safe harbour. *J Popul Sustain* 2022; 6: 51–61.
35. Elhacham E, Ben-Uri L, Grozovski J, et al. Global human-made mass exceeds all living biomass. *Nature* 2020; 588: 442–444.
36. Daly HE. The circular flow of exchange value and the linear throughput of matter-energy: a case of misplaced concreteness. *Rev Soc Econ* 1985; 43: 279–297.
37. Solow RM. The economics of resources or the resources of economics. *Am Econ Rev* 1974; 64: 1–14.
38. Dasgupta PS and Heal GM. *Economic theory and exhaustible resources*. Cambridge, UK: Cambridge University Press, 1980. doi:10.1017/CBO9780511628375.
39. Ritchie H, Roser M and Rosado P. Energy. *Our World Data*. <https://ourworldindata.org/fossil-fuels> (2022, accessed 20 June 20).
40. Stainforth T and Brzezinski B. More than half of all CO₂ emissions since 1751 emitted in the last 30 years – IEEP AISBL, <https://ieep.eu/news/more-than-half-of-all-co2-emissions-since-1751-emitted-in-the-last-30-years/> (2020, accessed 20 June 2023).
41. Kotler P. *Marketing management: Analysis, planning, implementation, and control*. New Jersey, USA: Prentice Hall, 1997.
42. Bernays EL. The engineering of consent. *Ann Am Acad Pol Soc Sci* 1947; 250: 113–120.
43. McGee LW and Spiro RL. The marketing concept in perspective. *Bus Horiz* 1988; 31: 40–45.
44. Sirgy MJ. Self-Concept in consumer behavior: a critical review. *J Consum Res* 1982; 9: 287–300.
45. Belk RW. Possessions and the extended self. *J Consum Res* 1988; 15: 139–168.
46. The Biggest Data Breach. <https://www.iccl.ie/wp-content/uploads/2022/05/Mass-data-breach-of-Europe-and-US-data-1.pdf> (accessed 20 June 2023).
47. SuperAwesome launches Kid-Safe Filter to prevent online ads from stealing children's personal data. SuperAwesome, <https://www.superawesome.com/superawesome-launches-kid-safe-filter-to-prevent-online-ads-from-stealing-childrens-personal-data/> (2018, accessed 20 June 2023).
48. Bruckner B, Hubacek K, Shan Y, et al. Impacts of poverty alleviation on national and global carbon emissions. *Nat Sustain* 2022; 5: 311–320.
49. Ahmed N, Marriott A, Dabi N, et al. *Inequality kills: The unparalleled action needed to combat unprecedented inequality in the wake of COVID-19*. Oxford, UK: Oxfam, 2022. doi:10.21201/2022.8465.
50. Bringezu S. Possible target corridor for sustainable use of global material resources. *Resources* 2015; 4: 25–54.

51. Akenji L, Lettenmeier M, Koide R, et al. *1.5-Degree lifestyles: targets and options for reducing lifestyle carbon footprints*. Espoo, Finland: Institute for Global Environmental Strategies, Aalto University, D-mat Ltd., 2019. doi:10.57405/iges-6719.
52. Trainer T. Remaking settlements for sustainability: the simpler way. *J Polit Ecol* 2019; 26: 219–221. doi:10.2458/v26i1.22972
53. Lockyer J. Community, commons, and degrowth at dancing rabbit ecovillage. *J Polit Ecol* 2017; 24: 519. doi:10.2458/v24i1.20890
54. Rao ND, Min J and Mastrucci A. Energy requirements for decent living in India, Brazil and South Africa. *Nat Energy* 2019; 4: 1025–1032. doi:10.1038/s41560-019-0497-9
55. Dasgupta A and Dasgupta P. Socially embedded preferences, environmental externalities, and reproductive rights. *Popul Dev Rev* 2017; 43(3): 405–441. doi:10.1111/padr.12090
56. Bajaj N and Stade K. Challenging pronatalism is key to advancing reproductive rights and a sustainable population. *J Popul Sustain* 2023; 7: 39–70.
57. Carroll L. *The baby matrix*. California, USA: Laura Carroll, 2012.
58. Bajaj N. Abortion bans are a natural outgrowth of coercive pronatalism. Ms. Magazine, <https://msmagazine.com/2022/06/07/abortion-bans-coercive-pronatalism-forced-birth/> (2022, accessed 20 June 2023).
59. Engelman R. *More: Population, nature, and what women want*. Chicago, USA: Bibliovault OAI Repos Univ Chic Press, 2010.
60. Hollingworth LS. Social devices for impelling women to bear and rear children. *Am J Sociol* 1916; 22: 19–29.
61. Kaklamanidou BD. The voluntarily childless heroine: a postfeminist television oddity. *Telev New Media* 2019; 20: 275–293.
62. Rottenberg C. Neoliberal feminism and the future of human capital. *Signs J Women Cult Soc* 2017; 42: 329–348.
63. Tsigdinos PM. An IVF survivor unravels ‘fertility’ industry narratives. *J Mark Manag* 2022; 38: 443–459.
64. Patrizio P, Albertini DF, Gleicher N, et al. The changing world of IVF: the pros and cons of new business models offering assisted reproductive technologies. *J Assist Reprod Genet* 2022; 39: 305–313.
65. Weisman A. Countdown. Our last, best hope for a future on earth?, <https://www.hachettebookgroup.com/titles/alan-weisman/countdown/9780316236508/> (2013, accessed 20 June 2023).
66. Tucker C. It’s time to revisit the Cairo consensus. *J Popul Sustain* 2021; 5: 63–73.
67. Nearly half of all pregnancies are unintended – a global crisis, says new UNFPA report. United Nations Population Fund, <https://www.unfpa.org/press/nearly-half-all-pregnancies-are-unintended-global-crisis-says-new-unfpa-report> (2022, accessed 20 June 2023).
68. Campbell M and Bedford K. The theoretical and political framing of the population factor in development. *Philos Trans R Soc B Biol Sci* 2009; 364: 3101–3113.
69. Michaux SP. The mining of minerals and the limits to Growth, https://tupa.gtk.fi/raportti/arkisto/16_2021.pdf (2021).
70. Michaux SP, Vadén T, Korhonen JM, et al. Assessment of the scope of tasks to completely phase out fossil fuels in Finland.
71. Michaux S. Review of 4 papers in context of work done affiliations, 2023.
72. Kalt G, Thunshirn P, Krausmann F, et al. Material requirements of global electricity sector pathways to 2050 and associated greenhouse gas emissions. *J Clean Prod* 2022; 358: 132014.
73. Nikiforuk A. The rising chorus of renewable energy skeptics. The Tyee, <https://thetyee.ca/Analysis/2023/04/07/Rising-Chorus-Renewable-Energy-Skeptics/> (2023, accessed 20 June 2023).

74. Gowdy J. Our hunter-gatherer future: climate change, agriculture and uncivilization. *Futures* 2020; 115: 102488.
75. La Ferrara E, Chong A and Duryea S. Soap operas and fertility: evidence from Brazil. *Am Econ J Appl Econ* 2012; 4: 1–31.
76. Negussie T. Hearing is believing. *Commun World* Published online April 2008.
77. Bergquist M, Thiel M, Goldberg MH, et al. Field interventions for climate change mitigation behaviors: a second-order meta-analysis. *Proc Natl Acad Sci U S A* 2023; 120: e2214851120.
78. Tversky A and Kahneman D. The framing of decisions and the psychology of choice. *Science* 1981; 211: 453–458.
79. Anderson J. What to call plant-based meat alternatives: A labeling study. Faunalytics, <https://faunalytics.org/what-to-call-plant-based-meat-alternatives-a-labelling-study/> (2019, accessed 20 June 2023).
80. Poças Ribeiro A, Harmsen R, Rosales Carreón J, et al. What influences consumption? Consumers and beyond: purposes, contexts, agents and history. *J Clean Prod* 2019; 209: 200–215.
81. The success of the “Pinkie” campaign, <https://acrs.org.au/files/papers/33%20Watsford%20The%20success%20of%20the%20pinkie%20campaign.pdf> (accessed 20 June 2023).
82. 92% of people feel ashamed to drink and drive as 50th anniversary THINK! campaign is launched. GOV.UK, <https://www.gov.uk/government/news/92-of-people-feel-ashamed-to-drink-and-drive-as-50th-anniversary-think-campaign-is-launched> (2014, accessed 20 June 2023).
83. Eckhardt GM, Belk RW and Wilson JAJ. The rise of inconspicuous consumption. *J Mark Manag* 2015; 31: 807–826.
84. Centola D, Becker J, Brackbill D, et al. Experimental evidence for tipping points in social convention. *Science* 2018; 360: 1116–1119.

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